1. (9 pts) True or False

(a) If a Carnot engine has T_{hot} = 60 °C and T_{cold} = 30 °C is efficiency is $\frac{1}{2}$.

TRUE

(b) If, for some process we find $\Delta E= -328.4$ J and $\Delta H= 218.3$ J then our system cannot be an ideal gas.

TRUE

FALSE

(c) Adq is always non-zero, for any possible cycle.

TRUE

FALSE

cycle com be adiabate

(d) q=0 for any adiabatic process, even if it is reversible.

TRUE

FALSE

defin of adiabatic

(e) The heat capacity of water depends upon whether or it is a gas or a liquid.

TRUE

FALSE

of course! Look up Criquid Vapor.

(f) All gases are ideal gases

TRUE

FALSE

uonder Waals

(g) pV is a state function.

TRUE

FALSE

are both state variables product is a state function

(h) $\frac{dq}{T}$ is always a state function.

TRUE

(i) Work is always calculated as Force*ΔX

constant.

2. (21 pts) Bob the Bass

Bob the Bass has a swim bladder containing 0.5 moles of an ideal gas $(C_v = \frac{3}{2}nRT)$. Assume that the swim bladder is a closed system.

(a) Bob the Bass swims from the surface of a lake, where the pressure is 1 atm, to a depth of 30 meters below the surface (where pressure is 2 atm). Suppose that during Bob's descent, his swim bladder contracts isothermally and reversibly. If his swim bladder is at a temperature of 25 °C, find ΔE , ΔH , q, and w (always in Joules) for the swim bladder.

$$\Delta T = 0 \quad \text{since isothermal}$$

$$\Delta E = CV \Delta T = 0$$

$$\Delta H = 0$$

$$\Delta H$$

= 959 J : q = -859 J worth | point

(b) At the depth of 30 feet (2 atm pressure), Bob is hooked by an angler. After a furious struggle, he is hauled to the surface (1 atm pressure). During this time period, Bob uses internal muscles so that the swim bladder is held at a constant volume (hint: the temperature must increase). Find ΔE, ΔH, q, and w (in Joules) for the swim bladder.

4
$$w=0$$
 constant volume process

 $T_2 = \frac{P_1 T_1}{P_2} = \frac{2atm}{1atm} \cdot 298K$
 $2pts$ for correct $\Delta E = 9 + y S = 9 = C_V \Delta T = \frac{3}{2} nR \Delta T$
 $equations$
 $= \frac{3}{2} (0.5 \text{ moe}) (8.314 \frac{J}{me.R}) (1980c - 298k)$
 $= -929 J$

1pt for
plugging in OH = CPAT = 気 NRAT = 気 (0.5 mol) (8.314 miles) (-149)
= 1.55 KJ

(c) Once on the surface, Bob's swim bladder expands until the volume and the temperature are the same as in part 1a. Find ΔE , ΔH , q, and w (in Joules) for the swim bladder.

since at latrn, constant pressure.

$$w = -P_{ext} \Delta V = -P_{ext} \left(\frac{nRT_f}{P_{ext}} - \frac{nRT_i}{P_{ext}} \right) = -nR\Delta t = -(0.5mol)(8.314 \frac{J}{melk})(+144)$$
for work
$$= -619.4 J$$

19th $q = \Delta H = \frac{1}{2} nR \Delta T = \frac{1}{2} (0.5 \text{ mol}) (8.314 \frac{J}{\text{mol}}) (149) = 1.55 \text{ kJ}$ 1pt for $\Delta E = q + W = 929 J$

Name:	4	6	

SID:

(d) Determine the total change in internal energy and enthalpy for the entire process starting from 1a and ending at 1c. Explain why you could have arrived at this answer without doing any calculation.

$$\Delta E=0$$
 } these are state functions,
 $\Delta H=0$ and Bob undergoes a complete cycle.

* 2 points for this *

(e) Determine the total work done and heat generated by parts 1a-c.

$$W_{Tot} = W_A + W_B + W_C = 859 J + 0J - 619 J = 240 J$$

$$Q_{tot} = 9_A + 9_B + 9_C = -859 J - 929 J + 1550 J = -238 J$$
rounding

this is enough for 2 pts

(f) How many times must be Bob be caught from a depth of 30 m, released, and allowed to swim down again to 3m before he passes away? If you didn't get an answer for part e assume a reasonable q and w.

Assume the following:

- Bob weighs 5 kg, and has the heat capacity of water (4.18 J/g K).
- All the heat from parts 1a-c are transferred directly to his body, and are not passed on to his environment.

• Bob dies at 40 °C.

m=# of times caught; total heat = m*(-9tot)

lvoint

$$M \cdot (-q + ot) = 5 kg \times 4.18 kJ (40-25 K)$$
 1 point

$$m = \frac{313.5 \text{ kJ}}{9 \text{ tot}} = \frac{313.5 \text{ kJ}}{238 \text{ J}} = 1317 \text{ times}$$

$$\frac{1}{2} = \frac{1}{2} = \frac{1}{$$

(g) Bob the bass is served for breakfast. In the process of preparing Bob for consumption, the following occurs:

Bob is heated from room temperature (30 °C) to 200 °C, where he undergoes a phase transition from raw fish to cooked fish. He is then allowed to cool down to room temperature.

Given that Bob weighs 5 kg and

$$C_{p,raw} = 4.18 \text{ J/g K}$$

1m)

Bob

 $C_{p,cooked} = 1.32 J/g K$

cooked

Bob-

 $\Delta H(200 ^{\circ}C)_{raw \rightarrow cooked} = 213.3 \text{ kJ/kg}$

Find $\Delta H(30 ^{\circ}C)_{raw\rightarrow cooked}$ in kJ/kg.

note: 4.10J

Le point for getting units
pugged in
correctly

AH = Cp, row AT AH = Cp, cooked (30-200)

Bob 200°C $\Delta H = 213.3 \text{ kJ} 200°C$

I point for Jetting path

= 6H(200°C) + 10 Cp, raw (200-30) + Cp, cooked (30-200) 5H(30°C) = 5H(200°C) + (Cp, raw - Cp, cooked) (200°C - 30°C) ← 1 point for correct signs

$$=213.3 \frac{kJ}{kg} + \left(\frac{4.18 \, kJ}{kg} - \frac{1.32 \, kJ}{kg}\right) (200-30)$$

= 213.3
$$\frac{kJ}{kg}$$
 + 486.2 $\frac{kJ}{kg}$ = 699.5 $\frac{kJ}{kg}$ adding convertly

3. (10 pts) One Shots for which we get credit, helshe may have received no credit due to the clearly contradictory/incorrect content of subsequent remarks. These questions require only very short answers. Keep your answers as short as possible; no more than

2-3 sentences. Anything after the third sentence will not be graded.

They mention $C_v = (\frac{\partial E}{\partial \tau})_v$ and $(p = (\frac{\partial H}{\partial \tau})_p$ and explicitly that H = E + PV(+4)(a) In general, C_v differs from C_p . Explain, physically, why this is true.

For a constant-volume process, heat is primarily absorbed via an increase in the kinetic energy of the molecules/atoms.

For constant-pressure processes, the volume can change; therefore, the heat is absorbed not only via an increase in KE, it is converted to work.

(+1) for Cp = Cu + R; or if they mention kinetic energy; or for $Cu = (3E/3T)_u$, $Cp = (3E/3T)_r$ (+3) if mention of more degrees of freedom/motion for V constant (b) Computational biologists utilize algorithms to predict what tertiary structures peptides will assume. Often these scientists use different thermodynamic quantities to judge whether a certain protein configuration is stable.

In one computer experiment, a scientist estimated from her calculations the entropy of a protein at 0 K and found that it did not equal zero. Is there something wrong with her algorithm? Explain.

The third law of thermodynamics states that S=0 at OK for a (+3) Perfect crystal. A protein is not a perfect crystal, hence it is reasonable for S>0 at OK.

(+2) For stating that the prokin may have different allowed configurations

(d) A Protein crystallographer's biggest challenge is to obtain high quality crystals of protein. The proteins in a solution, under proper conditions, will come together in an ordered, regular arrangement.

Using what you know about thermodynamics explain how it is possible to form this highly-ordered, crystalline structure from a disordered solution.

While Asprotein <0 from crystallization, the crystallization process can be exothermic, releasing heat into the surroundings and causing Assurr >0. As long as Astotal = Assurr + Asprotein >0, this process is thermodynamically allowed.

also accepted: Évaporation of the solvent will produce an increase in ASsurr which compensates for ASprotein KO (ASsurr + ASprotein &O)

(+2) For mentioning 18H or release of heat (+1)
(+3) For mentioning ASsys + ASsurr > 0

For mentioning cooling (ges, at or close to OK there would be less available configurations...)

No credit if cooling was mentioned without extlaining why!

4. (10 pts) Bond Energies

Consider the following reaction in which two aspartic acid molecules join to form a dipeptide.

What is ΔH_r , based on the bond dissociation energies from the information page?

erther way.

Bonds broken: 1 (N-H)

+1 pt each for identifying the bonds and the number of tem converting +1 pt for DHr = \(\int \) (Groken) - \(\int \) (formed)

4 hours equivalent

AHr= + 102 KJ/nol = accorate

AHr= + 468 KJ/nol = as 5 cm

+ 4xts synersistic
Vorked at

points for have, everything convectly

5. (10 pts) Chemical Reactions

0.727 grams of D-ribose ($C_5H_{10}O_5$) is placed in a calorimeter and ignited in the presence of excess oxygen, causing the temperature to rise by 0.910 K.

(a) What is the balanced reaction of the combustion (assuming complete conversion into CO_2 and $H_2O)$?

$$\frac{1}{1} \text{pt} - 501 + C5460_5 \rightarrow 500_1 + 5410$$

(b) To calibrate your calorimeter you combust 6.76*10⁻³ moles of benzoic acid, which has a heat of combustion of -3251 kJ/mol; this causes the temperature to rise by 1.940 K. What is the heat capacity if the calorimeter?

(c) Using your result from part b (if you didn't answer part b assume the heat capacity was +10 kJ/K), calculate ΔH of combustion for D-ribose (i.e. ΔH_r for the reaction you wrote in part a)

(d) Using your result from part c (if you didn't get answer use ΔH_r = -1000 kJ/mol), and the values from the tables on the information page, calculate ΔH_f for D-ribose.